3P4-1

Development of droplet manipulation system using surface acoustic wave

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1. Introduction

Currently, large numbers of samples are tested manually in the medical and biotechnology fields, and microfluidic systems that integrate functions such as transport, mixing, and analysis on a single substrate are required to improve the efficiency of testing and to save space in experiments. As a method of moving a minute amount of liquid, there is electrowetting method that moves droplets by controlling the contact angle of the droplets by an electric field and moving a droplet by exciting a surface acoustic wave (SAW) using a piezoelectric substrate and an interdigital transducer (IDT).[1,2)] In the method using SAW, a droplet is placed on the SAW propagation path and longitudinal waves are radiated into the droplet, creating a streaming in the droplet and enabling transportation. In addition, it has the advantage that mixing and heating can be performed simultaneously with conveying. Conventional SAW devices are designed for SAW propagation in the direction of 0° 3rd Euler angle on 128°Y-cut $LiNbO_3$.[2)] Therefore, droplets could be transported in only one direction, and it was not possible to transport droplets to multiple sensors or to transport multiple droplets at the same time. In this study, we designed IDTs with different directions on one substrate and performed droplet transfer using SAW excited from each IDT, and compared the transfer of each IDT.

2. Experimental method

The piezoelectric substrate used in this study is 128°Y-cut$LiNbO_3$. **Figure 1** shows a schematic diagram of the designed and fabricated SAW device. The IDTs were created so that the SAW propagation directions were 0° and 30° 3rd Euler angles, respectively, as shown in Figure 2. The propagation velocity of the SAW (v_{SAW}) excited by each IDT, the Rayleigh angle (θ_R), and the electromechanical coupling coefficient (k^2) are listed in **Table 1**. The experimental system is shown in **Figure 2**. A 2 μL droplet is dropped on the piezoelectric substrate and SAW is excited at 0.7 W. Droplet shape changes during SAW droplet transfer. To prevent this as much as possible, the propagation path of the SAW is hydrophobically treated with acetone. Droplets are transported by SAW. This was captured by a video camera. The distance between the center of the IDT and the center of the droplet at the end of the transfer (L) and the angle between the normal direction of the IDT and the center of the droplet (φ) was measured from this movie using ImageJ, as shown in **Figure 3**.

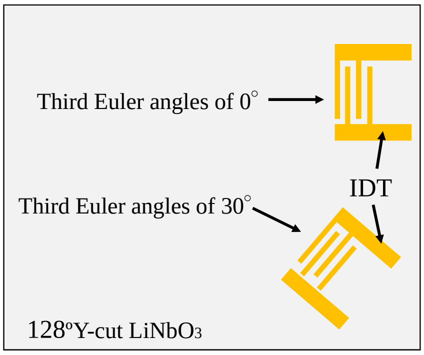

Fig. 1 Schematic diagram of the created SAW device

Table 1 Propagation velocity (v_{SAW}) of SAW excited by the third Euler angles of 0° and 30°, Rayleigh angle (θ_R), and electromechanical coupling coefficient (k^2).

Third Euler angles [°]	v_{SAW} [m/s]	θ_R [°]	k^2 [%]
0	3977	22.2	5.4
30	3725	23.7	3.0

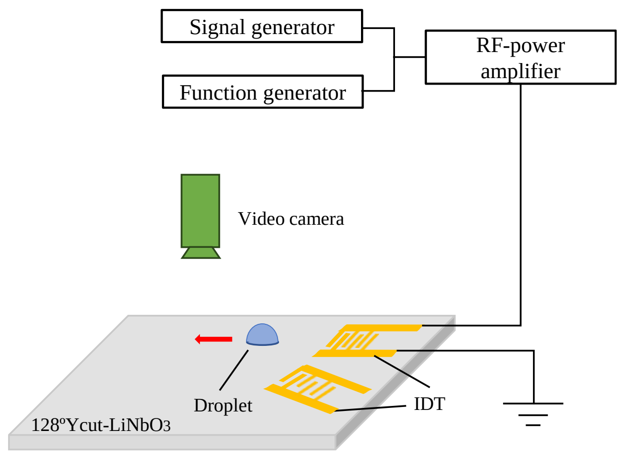

Fig. 2 Experimental system

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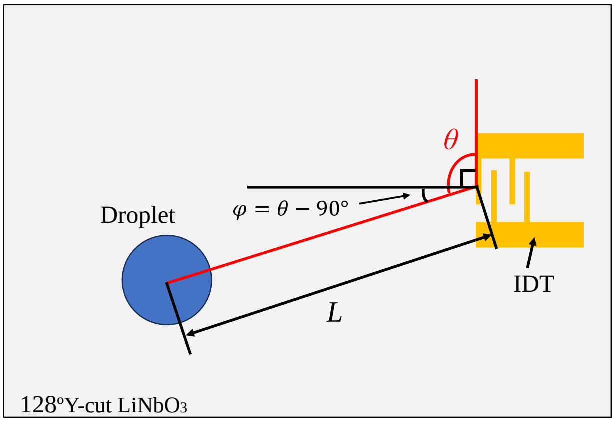

Fig. 3 Measured distance (L) and angle (φ)

3. Results and discussion

Table 2 shows the results of droplet transfer with SAW excited at the third Euler angle of 0° and 30° IDT. When an IDT with a third Euler angle of 0° was used, droplets were transported to the edge of the piezoelectric substrate. When an IDT with a third Euler angle of 30° was used, the droplets did not travel to the edge of the piezoelectric substrate and stopped at a point about 10 mm away. This is due to a change in the excitation of the SAW by changing the direction of propagation of the SAW.

The particle displacement distribution of SAW was therefore obtained using numerical analysis. The particle displacement distribution of the SAW when using IDT with third Euler angles of 0° and 30° are shown in **Figures 4 and 5**. The longitudinal wave and SV components do not change significantly. However, the SH component was found to be larger when an IDT with a third Euler angle of 30° was used than when an IDT with a third Euler angle of 0° was used. The results suggest that the SH component affected the droplet transport, causing the droplets to not reach the edge of the piezoelectric substrate and stop halfway through the transport.

Table 2 The distance between the center of the IDT and the center of the droplet at the end of transfer (L) and the angle between the normal direction of the IDT and the center of the droplet (φ).

Third Euler angles [°]	L [mm]	φ [°]
0	16.17	1.30
30	10.88	-0.92

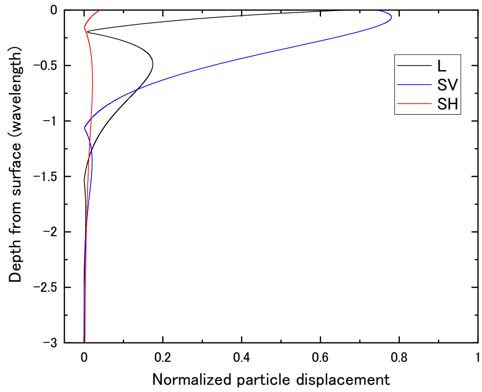

Fig. 4 The particle displacement distribution of the SAW when using IDTs with third Euler angles of 0°.

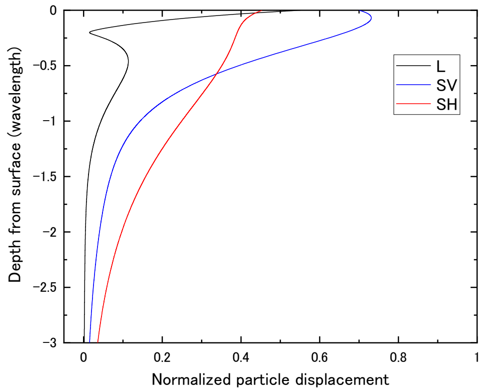

Fig. 5 The particle displacement distribution of the SAW when using IDTs with third Euler angles of 30°.

4. Conclusion

In this study, IDT with different SAW propagation directions were fabricated on a single substrate and compared. When the IDT with the third Euler angle of 0° was used, droplets could be transported to the edge of the piezoelectric substrate, but when the IDT with the third Euler angle of 30° was used, droplets could not be transported to the edge of the substrate. It was found that changing the direction of propagation of SAW affects droplet transport using SAW.

We will continue to study the effects of different SAW propagation directions.

References

1) R. Baviere, J. Boutet, and Y. Fouillet, Microfluidics and Nanofluidics, 2008, p. 287-294.
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